Using Dual-Regression to Produce 16-Day Average AIRS Soundings

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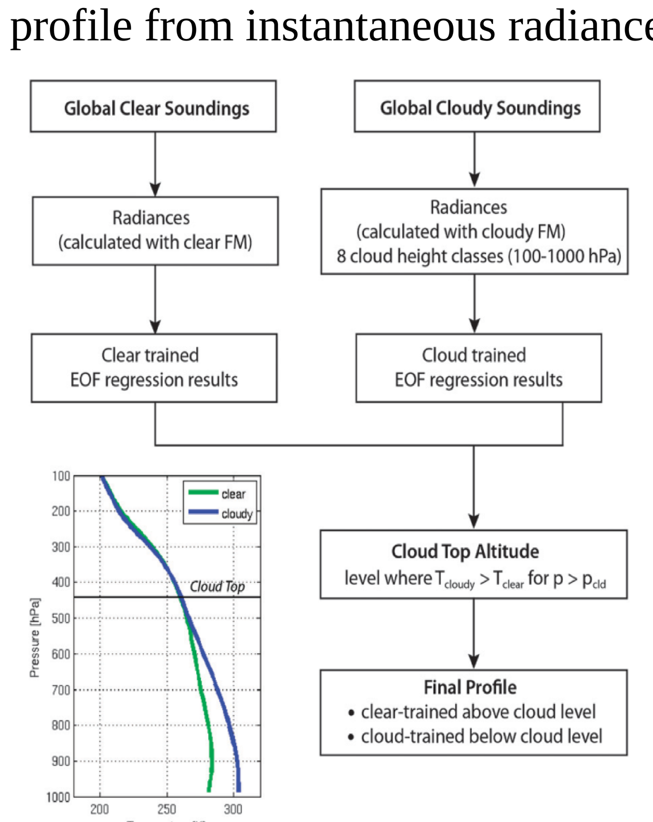
1. Introduction

- The Clouds and the Earth's Radiance Energy System (CERES) team uses temperature and moisture profiles from a NASA reanalysis product to compute surface irradiances.
- Any biases in the monthly regional mean reanalysis temperature and humidity profiles need to be corrected using observations.
  - We use polar hyperspectral sounder radiance data and the linear dual-regression (DR) retrieval approach (Smith et al. 2012) in this study.
  - One issue with using instantaneous data for climatological studies is the amount of instantaneous data that must be produced to cover larger time-periods needed for climate studies.
- Moving toward correcting the monthly regional reanalysis temperature and humidity profile, we test whether the bias correction derived from averaged clear-sky spectral radiance agree with mean of biases derived from instantaneous clear-sky spectral radiances.

2. Data and Methodology

- The polar hyperspectral data that is used in this study is Atmospheric Infrared Sounder (AIRS) radiance data.
  - We separate the AIRS clear-sky spectral radiances into a viewing zenith angle between near-nadir (1.6 to 24.8 degrees) and off-nadir (25.9 to 49 degrees).
  - We also separate the AIRS data into ascending (daytime) and descending (nighttime) orbits.
- The dual-regression algorithm (Smith et al. 2012) derives temperature and humidity profiles using off-line calculated regression coefficients
- For this study, this dual-regression is used testing the consistency of retrieved temperature and humidity profiles in two different ways for multiple 16-day periods:
  - First, temperature and humidity profiles are retrieved from instantaneous spectral radiances by the dual-regression algorithm, which subsequently are averaged to produce a 16-day average profile (hereinafter AVG(DAT)).
  - Second, instantaneous spectral radiances are averaged over a 16-day period and then input to the dual-regression algorithm to produce a 16-day averaged profile (hereinafter AVG(RAD)).
- These two methods are then compared to each other to see whether averaged temperature and humidity profiles AVG(RAD) agree with the averaged retrieved profile from instantaneous radiances AVG(DAT).



Flowchart of the dual-regression algorithm (Smith et al. 2012).

3. Results and Plots

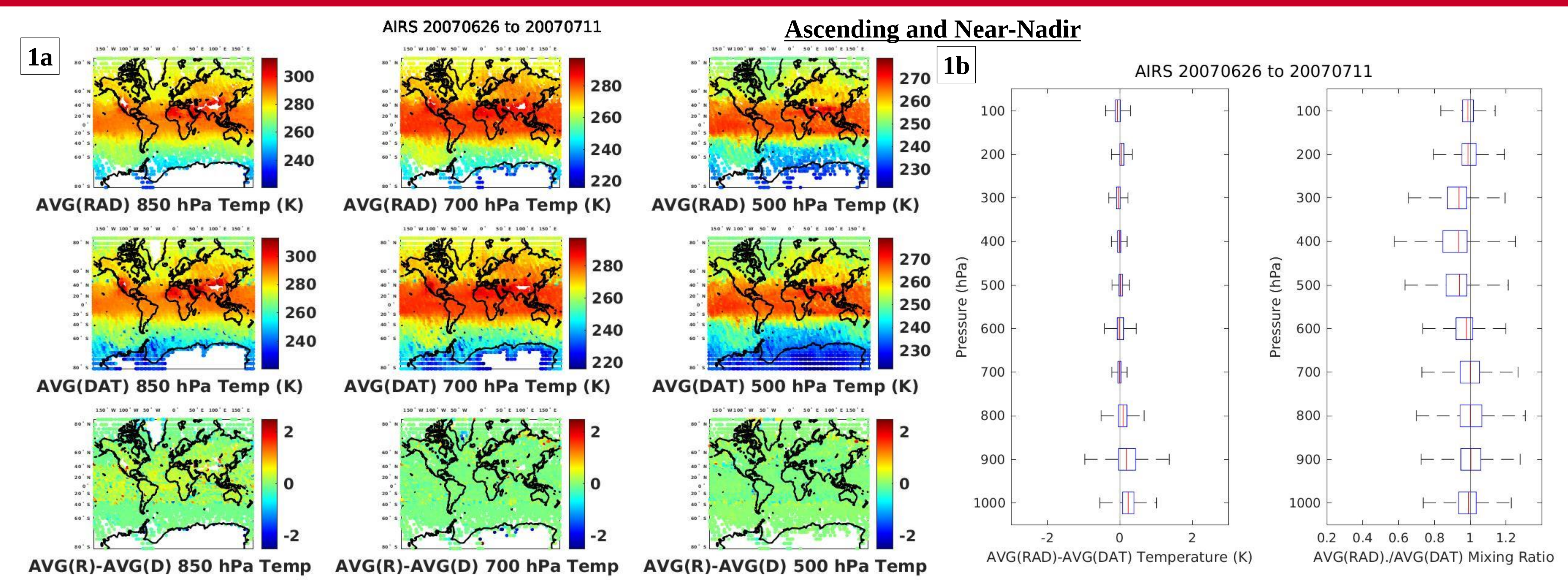


Figure 1. Results between AVG(RAD) and AVG(DAT) for daytime orbits between 1.6 and 24.8 viewing zenith angle including **(a)** global temperature in Kelvin and temperature difference and **(b)** vertical statistics showing difference for temperature and ratio of specific humidity of all data within 2 times the standard deviation (95%). The red line is the median, the blue box shows 50% of the data, and the error bars show the range of the data.

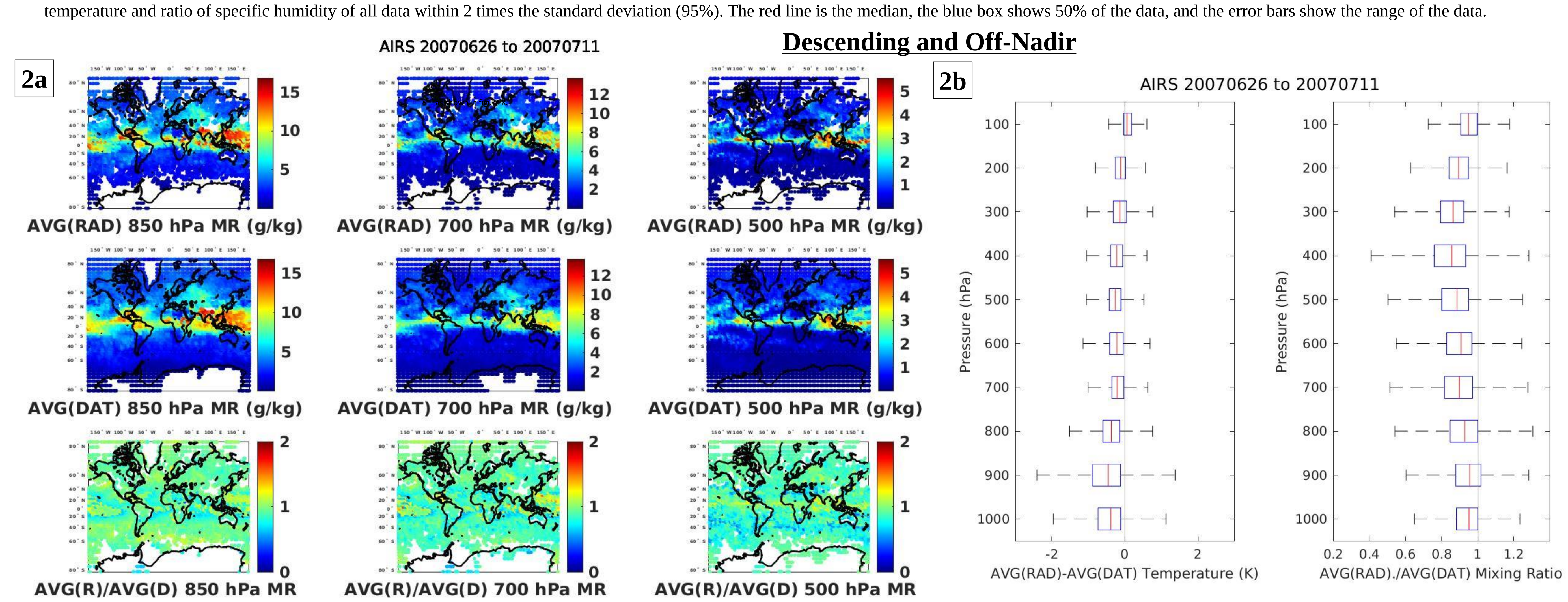
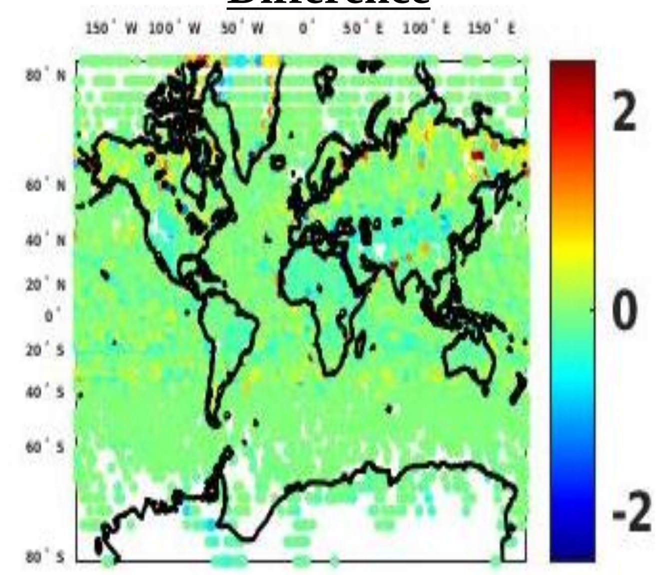
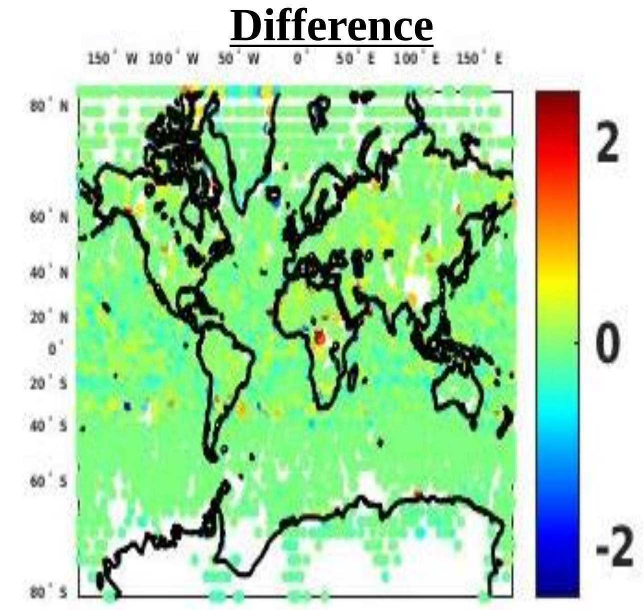


Figure 2. Results between AVG(RAD) and AVG(DAT) for nighttime orbits between 25.9 and 49 viewing zenith angle including **(a)** global specific humidity in g/kg and specific humidity difference and **(b)** vertical statistics showing difference for temperature and ratio of specific humidity of all data within 2 times the standard deviation (95%). The red line is the median, the blue box shows 50% of the data, and the error bars show the range of the data.

Ascending Skin Temperature Difference



Descending Skin Temperature Difference



Asc+Des Skin Temperature Difference

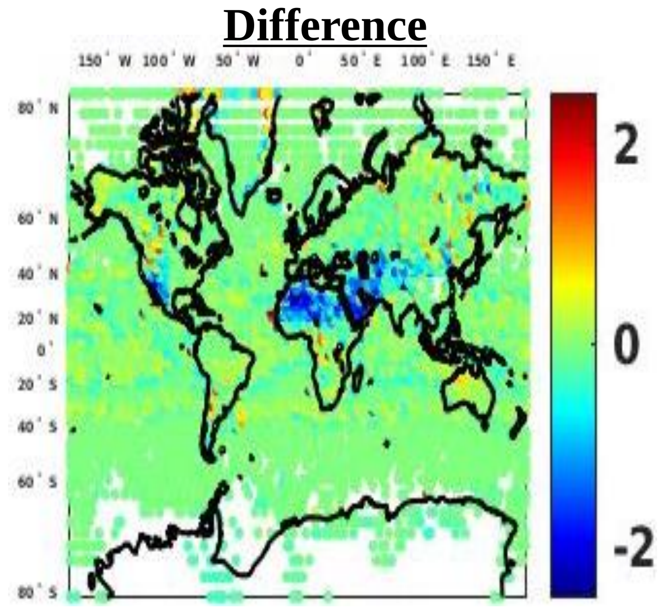


Figure 3. Global skin temperature difference between AVG(RAD) and AVG(DAT) for daytime orbits (top), nighttime orbits (middle), and all orbits (bottom).

4. Results and Conclusions

- The dual-regression algorithm can be used to produce 16-day averaged retrievals which will allow us to directly evaluate mean temperature and humidity profiles with averaged spectral radiances for climate applications.
- The results for clear-sky radiances show good agreements between the instantaneous data and the averaged radiance data and are consistent with our expectation because of a linear relationship between spectral radiance and temperature and humidity assumed for the DR retrieval algorithm application.
  - The mean temperature difference is between -0.1 and 0.3 K and the ratio of specific humidity is between 0.9 and 1.05 for near-nadir radiances, as shown in figure 1b.
  - The mean temperature difference is between -0.6 to 0.2 K and the ratio of specific humidity is between 0.84 and 0.94 for off-nadir, as shown in figure 2b.
- Good results hold for viewing zenith angles less than 49 degrees, but the difference is larger for larger viewing zenith angles.
- Separating ascending radiances from descending does not impact results much, besides regions with a large diurnal cycle of skin temperature (deserts) are benefitted by separating radiances into ascending and descending orbits, as shown in figure 3.
- This result is the first step toward for correcting mean regional temperature and humidity profiles using mean spectral radiances to constrain monthly mean temperature and humidity profiles directly by observed spectral radiances.

5. Future Work

- Run the average radiance dual-regression on all-sky conditions.
- Produce average radiance retrievals for other polar hyperspectral sounders, like Cross-track Infrared Sounder (CrIS).
- Start using the results from the average radiance retrievals to compare to reanalysis data and correct any biases found.

References

- Smith, W. L., Sr., E. Weisz, S. Kireev, D. K. Zhou, Z. Li, and E. E. Borbas, 2012: Dual-regression retrieval algorithm for real-time processing of satellite ultraspectral radiances. J. Appl. Meteor. Climatol., 51, 1455–1476, https://doi.org/10.1175/JAMC-D-11-0173.1.

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